

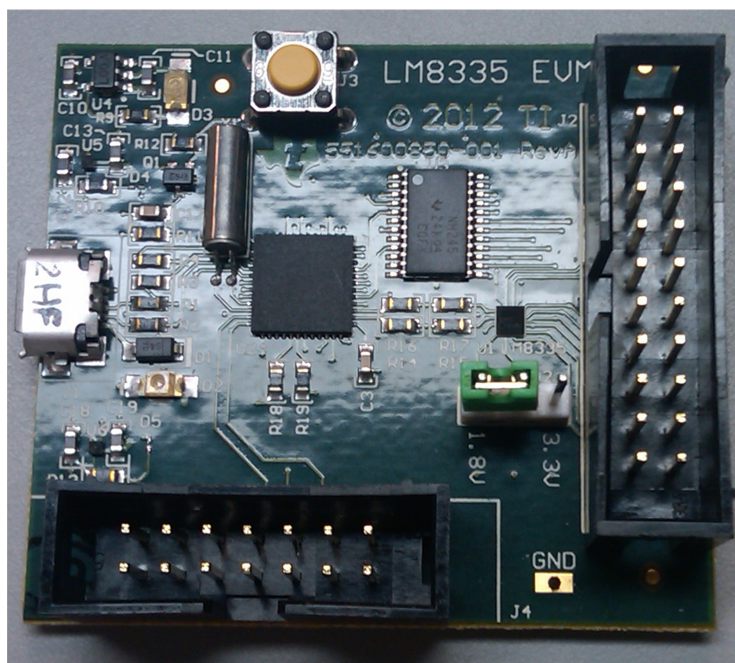
## **AN-2298 LM8335 Evaluation Module (EVM)**

### **1 Introduction**

The Texas Instruments LM8335EVM evaluation module (EVM), [Figure 1](#), helps designers evaluate the operation and performance of the LM8335 MIPI RFFE to General Purpose Output (GPO) Expander. The EVM contains a USB to MIPI RFFE converter (MSP430F5510), three LDOs, a 74LVC8T245 buffer for self-test, and the LM8335 (see [Table 1](#)).

**Table 1. Device and Package Configurations**

| Converter | IC                  | Package  |
|-----------|---------------------|----------|
| U1        | LM8335              | DSBGA-16 |
| U2        | MSP430F5510         | 48VQFN   |
| U3        | 74LVC8T245PWRE4     | PW024    |
| U4        | LP2980AIM5-3.3/NOPB | SOT23    |
| U5        | LP5990              | DSBGA-4  |
| U6        | LP5990              |          |



**Figure 1. LM8335EVM**

## 2 LM8335 EVM Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up and test the LM8335EVM Evaluation Board.

### 2.1 Input/Output Connector Description

- **J1 – Input** is the USB input connector. This connector provides USB data communication, 5V Power In, and ground (GND) connection.
- **J2 – Input/Output** is the MIPI RFFE input/output and GPO output connector. This connector provides MIPI RFFE communication to an external device and access to the LM8335 GPO outputs.
- **J4 – Input/Output** is the connector used to program the MSP430. This connector uses the standard interface for programming the MSP430 using the MSP-FET430UIF Debug-Interface Tool.
- **VDDIO2 – VDDIO Select** is the jumper used to select the VDDIO voltage used by the LM8335.

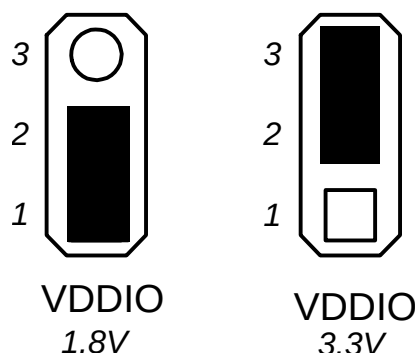


Figure 2. LPM Jumper Settings

### 2.2 Setup

For proper operation of the LM8335, the VDDIO2 jumper should be properly configured. The recommended setting, using shorting blocks: VDDIO to 1.8V

### 2.3 Operation

The LM8335EVM evaluation board is powered by the USB interface, no external supply is required. Connect the micro-USB type B cable to the LM8335EVM and to the PC. Launch the LM8335EVM GUI to access the features on the evaluation board.

## 3 Board Layout

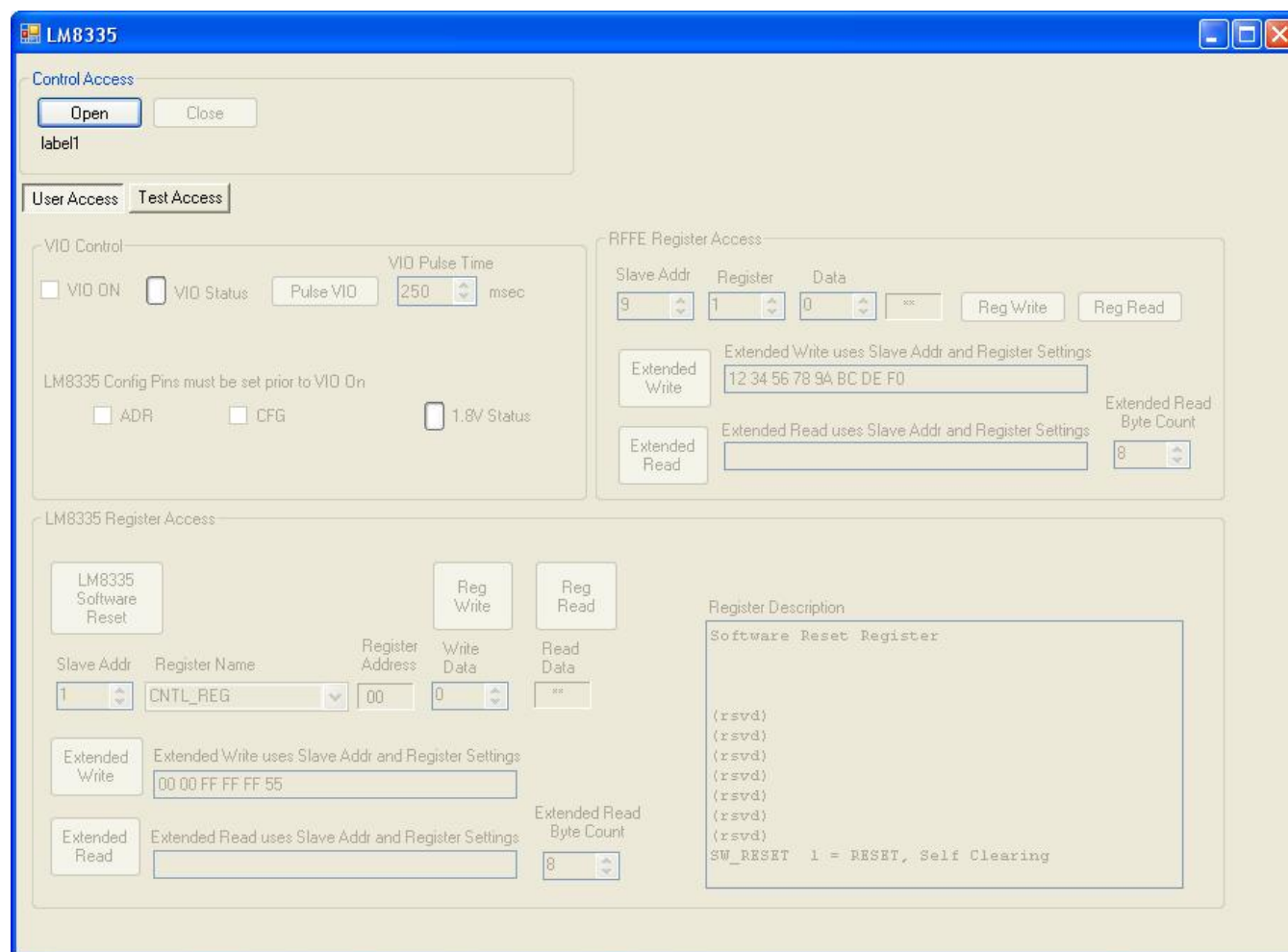
The LM8335 GPO output pins can be accessed via the J2 connector. Additionally the LM8335 EVM can be used to communicate with additional devices that comply with the MIPI RFFE specification using the 20-pin connector J2. Note that the cable required to communicate with an external MIPI RFFE device is not included. The connector J4 is provided only for initial programming of the MSP430 and should not be used by the customer.

## 4 LM8335 Evaluation Board

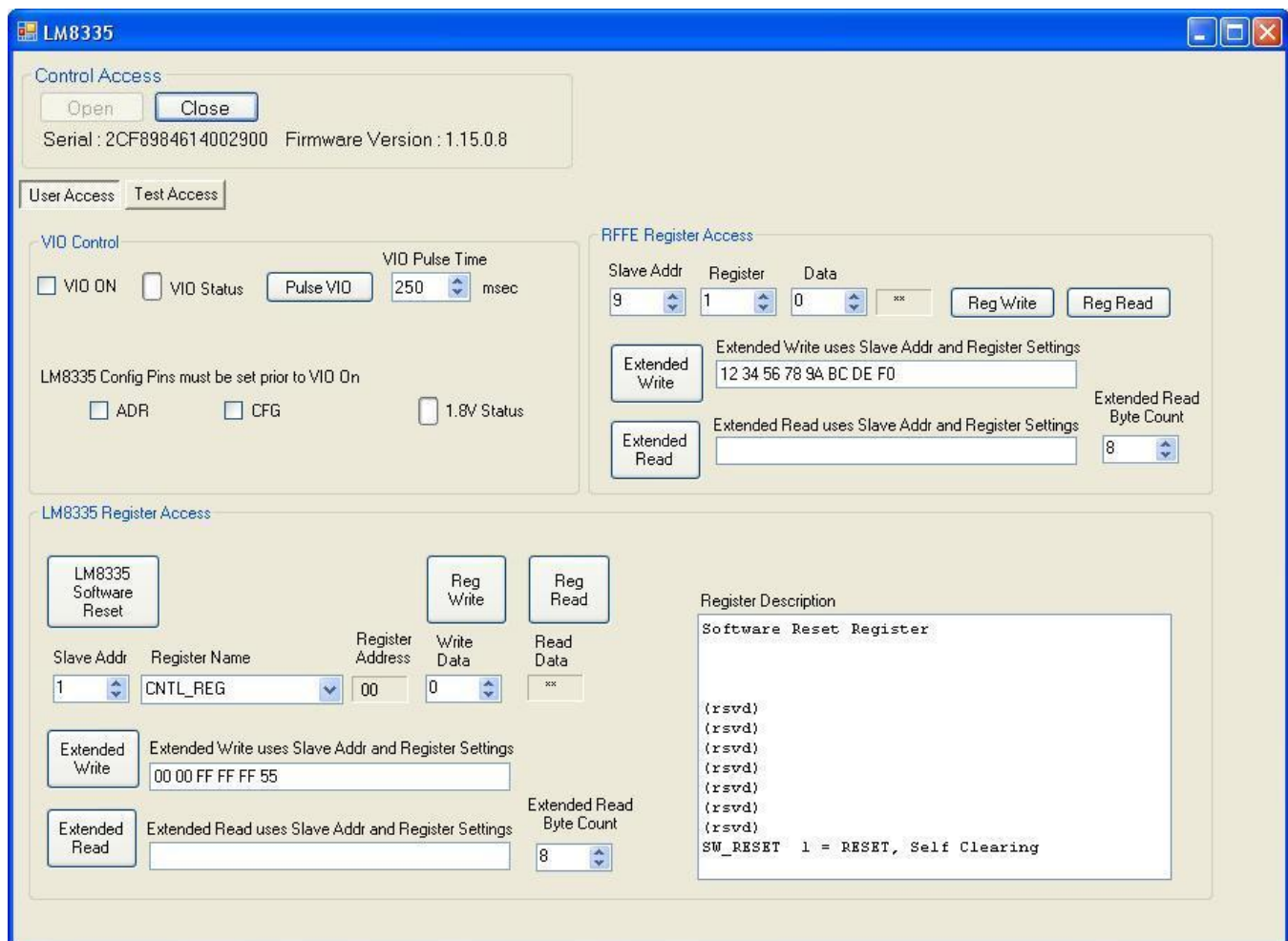
The LM8335EVM supports the MIPI RFFE register 0 write, register write, register read, extended register write, extended register read, extended register write long and extended register read long command sequences at 400 Khz SCLK rate.

## 5 LM8335 GUI

The LM8335EVM GUI will initially start with all access disabled with the exception of the Open button (refer to [Figure 3](#)). Clicking this button will initialize the USB interface between the PC and the LM8335EVM. When the USB connection is successfully opened the Serial: and Firmware Revision: fields will be populated with the LM8335EVM values (refer to [Figure 4](#)). If the LM8335EVM is not recognized by the PC the Serial: and Firmware Revision: fields will be populated with the word Error (refer to [Figure 5](#)).



**Figure 3. LM8335EVM GUI Initial Screen**



**Figure 4. LM8335EVM Open Successful Screen**



The LM8335EVM GUI provides user access and LM8335 self-test access.

## 5.1 User Access Tab

The User Access tab (refer to [Figure 4](#)) is partitioned into 4 sections:

1. Control Access: this section establishes USB communication to the LM8335EVM.
2. VIO Control: this section is used set the LM8335 ADR and CFG pin starts, turn VIO on, turn VIO off, pulse VIO and provides the VIO and 1.8V status indicators.
3. LM8335 Register Access: this section is used to access the LM8335 registers 4).
4. MIPI RFFE Register Access: this section can be used to access an external MIPI RFFE device.

The normal sequence to access the LM8335EVM is:

1. Click the Open button and verify the USB interface was successfully established.
2. Select the desired state of the ADR and CFG inputs (no check = low, check = high).
  - Note: the state of the ADR input automatically sets the Slave Addr field in the LM8335 Register Access section of the LM8335EVM GUI.
3. Click the VIO ON checkbox.
4. Perform the desired register write/read operation using the Register Name & Write Data dialog along with the Reg Write and Reg Read buttons.

The MIPI RFFE Register Write and Read access is performed as:

1. The LM8335 register is selected via the Register Name select box in the LM8335 Register Access section of the LM8335EVM GUI.
2. Clicking the Reg Write button will perform a single register write to the selected Register Name with the data contained in the Write Data box.
3. Clicking the Reg Read button will perform a single register read from the selected Register Name and place the value in the Read Data status box.

The MIPI RFFE Extended Register Write and Read access is performed as:

1. Clicking the Extended Write button will write the data contained in the text line adjacent to the Extended Write button starting at the selected Register Name address. (Note the data entered in the text line is hexadecimal format with a single space between bytes as illustrated by the default data pattern: 00 00 FF FF FF 55).
2. When performing the Extended Read command the number of bytes needs to be entered in the Extended Read Byte Count field prior to clicking the Extended Read button. The data is read starting at the address indicated by the Register Name dialog and is placed in the text line adjacent to the Extended Read button.

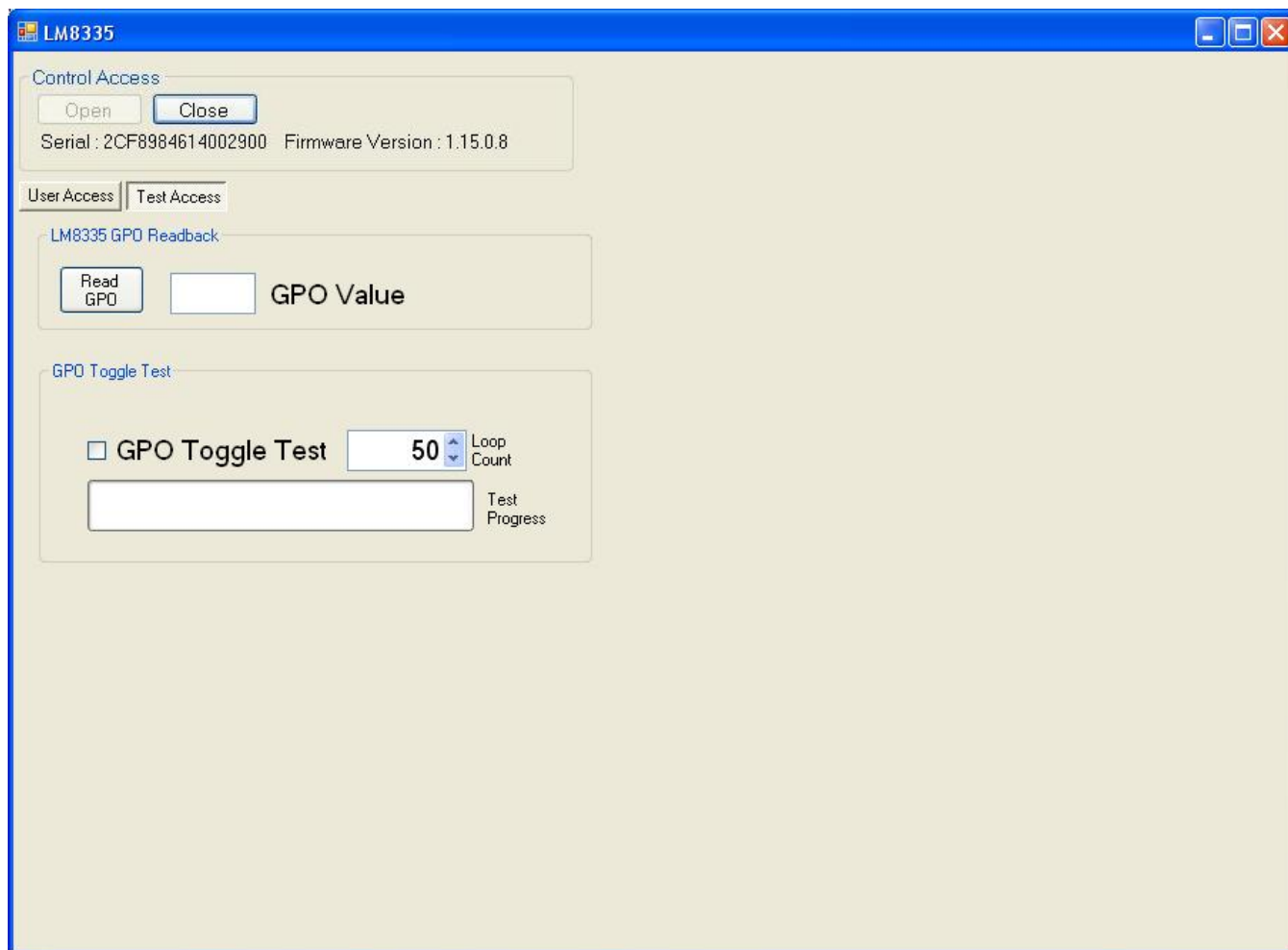
The MIPI RFFE access to an external MIPI RFFE device is performed in a similar manner using the MIPI RFFE Register Access section of the LM8335EVM GUI.



## 5.2 Test Access Tab

The Test Access tab (refer to [Figure 6](#)) is partitioned into 2 sections:

1. LM8335 GPO Readback: this section is used to verify the LM8335 GPO outputs. Clicking the Read GPO button will perform a walking one test of the LM8335 GPOs. The test starts with the value of 1 (GPO0) and advances to 80 (GPO7). The test will wrap from 80 back to 1 and can be repeated indefinitely by continuing to click the Read GPO button.
2. GPO Toggle Test: this section will cause the LM8335 to toggle between the values 0x55 and 0xAA for the number of times entered in the Loop Count box after the GPO Toggle Test checkbox is clicked.



**Figure 6. Test Access Tab**

## 6 LM8335 EVM Layout

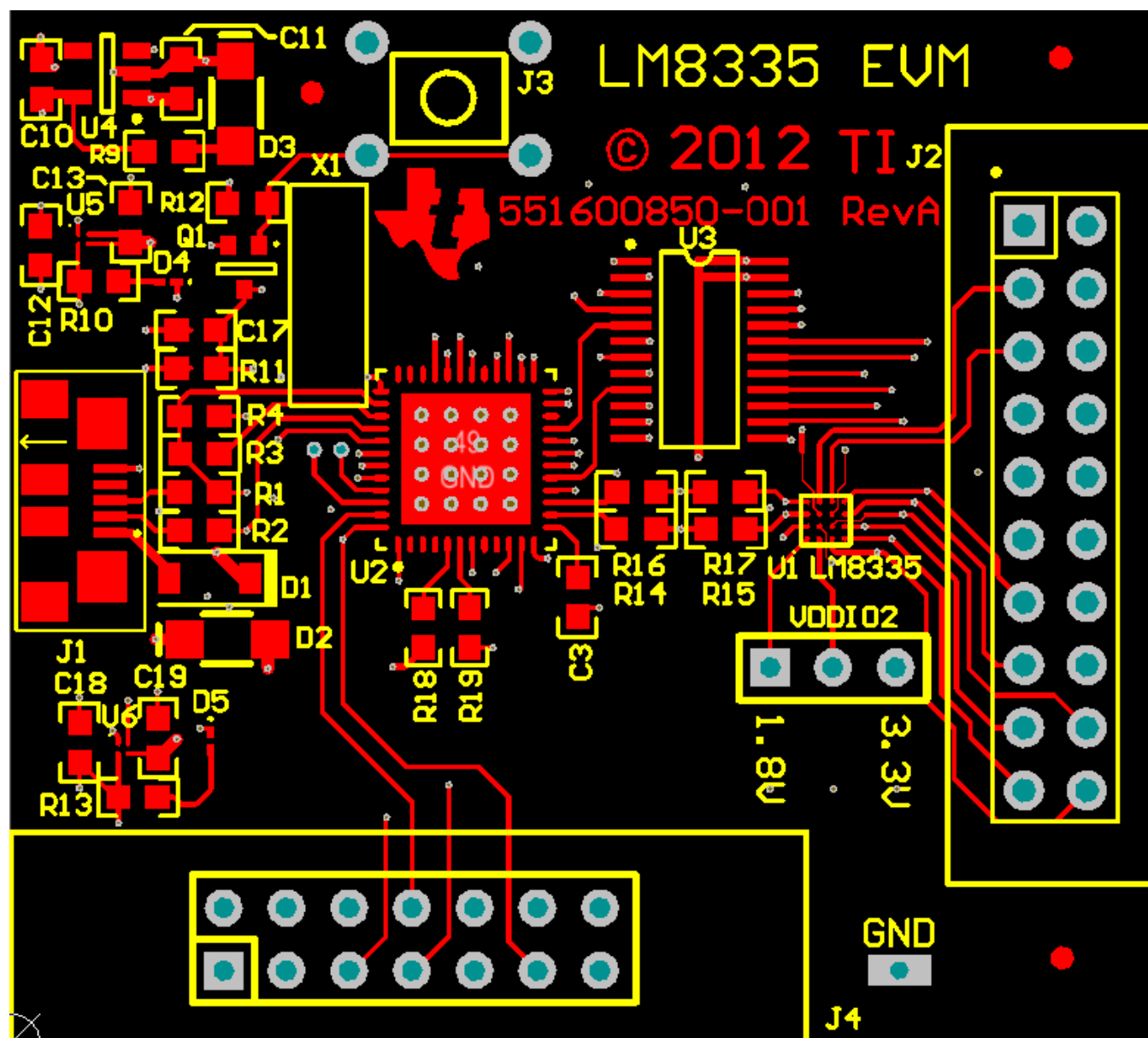


Figure 7. Top Assembly Layer



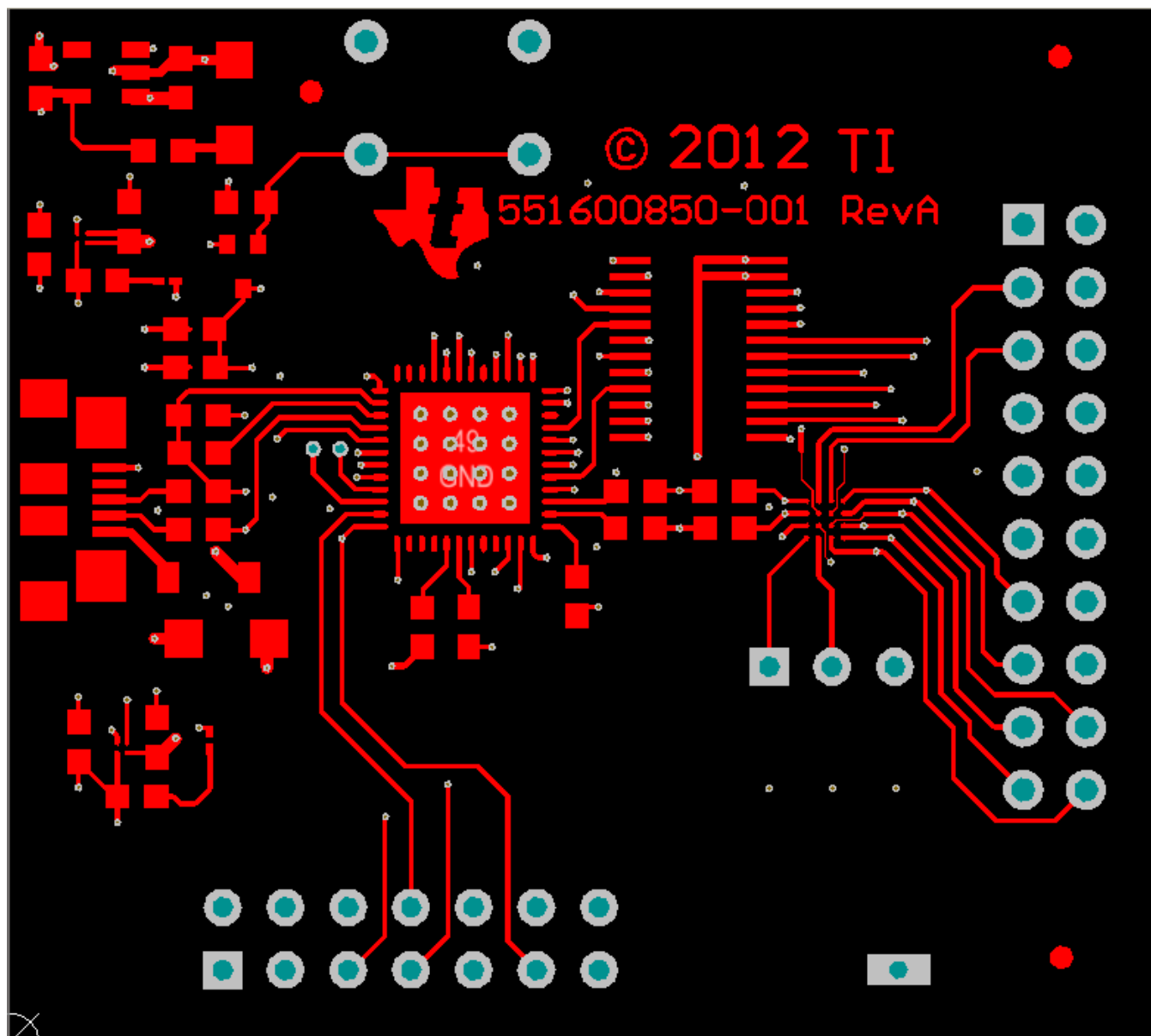


Figure 8. Top Layer Routing

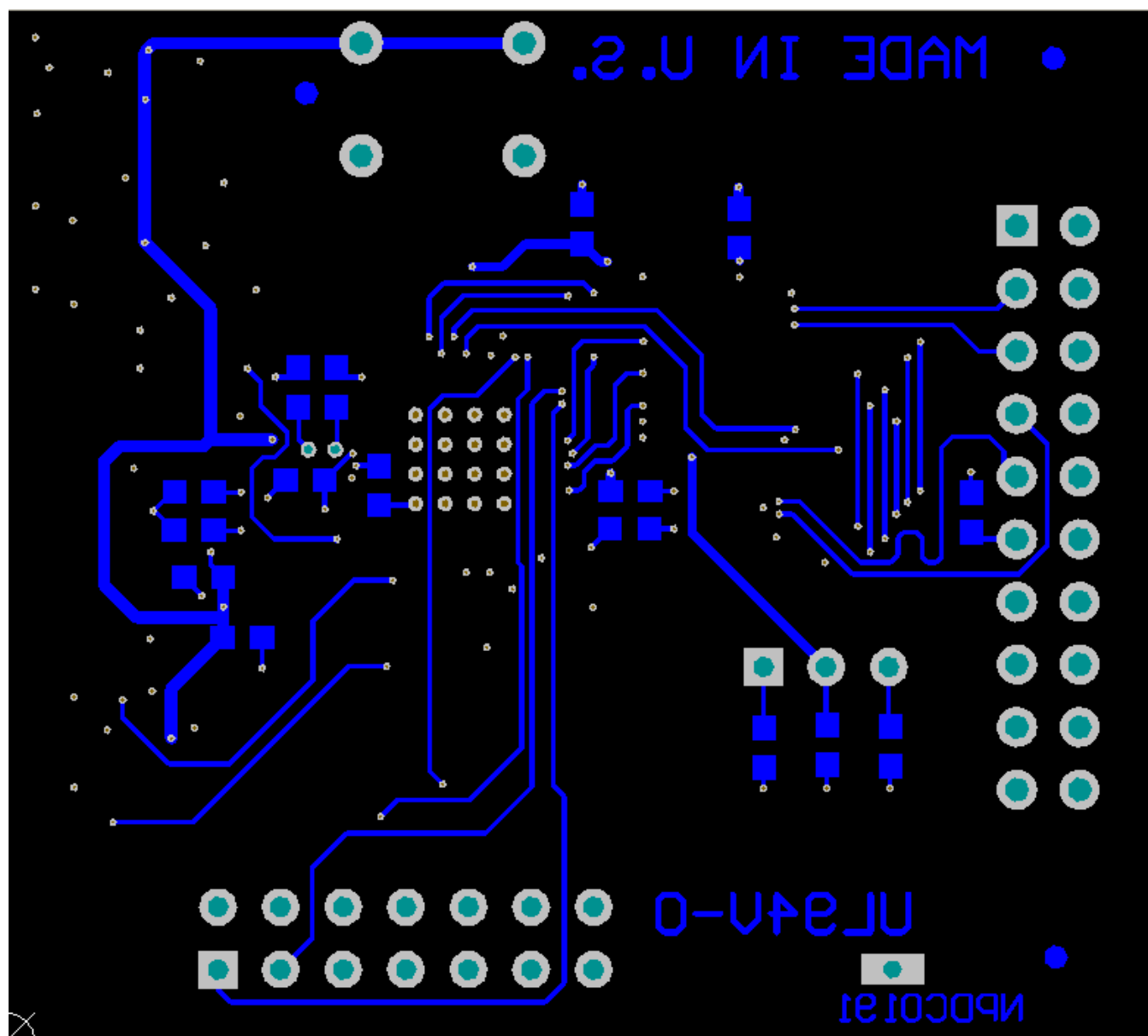


Figure 9. Bottom Layer Routing

## 7 LM8335 Bill of Materials

| Qty | Designator                   | Description                                | Part Number             | Footprint      |
|-----|------------------------------|--------------------------------------------|-------------------------|----------------|
| 2   | C1, C5                       | CAP, CERM, 20 pF, 50V, ±5%, C0G/NP0, 0603  | GRM1885C1H200JA01D      | 603            |
| 1   | C2                           | CAP, CERM, 0.22 µF, 25V, ±10%, X5R, 0603   | 06033D224KAT2A          | 603            |
| 2   | C3, C4                       | CAP, CERM, 0.4 7µF, 16V, ±10%, X7R, 0603   | C0603C474K4RACTU        | 603            |
| 2   | C6, C7                       | CAP, CERM, 10 pF, 50V, ±5%, C0G/NP0, 0603  | 06035A100JAT2A          | 603            |
| 1   | C8                           | CAP, CERM, 4.7 µF, 10V, ±10%, X5R, 0603    | C0603C475K8PACTU        | 603            |
| 1   | C9                           | CAP, CERM, 2.2 µF, 10V, ±10%, X5R, 0603    | C0603C225K8PACTU        | 603            |
| 6   | C10, C11, C12, C13, C18, C19 | CAP, CERM, 1 µF, 10V, ±10%, X5R, 0603      | C0603C105K8PACTU        | 603            |
| 5   | C14, C15, C16, C22, C23      | CAP, CERM, 0.1 µF, 16V, ±5%, X7R, 0603     | 0603YC104JAT2A          | 603            |
| 1   | C17                          | CAP, CERM, 1000 pF, 16V, ±10%, X7R, 0603   | GRM188R71C102KA01D      | 603            |
| 2   | C20, C21                     | CAP, CERM, 6.8 pF, 50V, ±4%, C0G/NP0, 0603 | 06035A6R8CAT2A          | 603            |
| 1   | D1                           | Diode, Schottky, 40V, 0.35A, SOD-123       | SD103AW-7-F             | SOD-123        |
| 2   | D2, D3                       | LED 3X1.5MM 568NM GN WTR CLR SMD           | APL3015SGC-F01          | 1206L DIODE    |
| 1   | J1                           | CONN RCPT MICRO USB B SMD R/A              | ZX62R-B-5P              | ZX62R-B-5P     |
| 1   | J2                           | CONN HEADER 20POS DL STR GOLD              | 30320-6002HB            | TSW-110-07-G-D |
| 1   | J3                           | SWITCH TACT 6MM MOM 150GF                  | B3F-1002                | B3F-1002       |
| 1   | J4                           | CONN HEADER 14POS DL STR GOLD              | 30314-6002HB            | IDC14nat       |
| 1   | Q1                           | MOSFET N-CH 30V 900 mA SOT323-3            | SI1304BDL-T1-E3         | SC-70-3-VISHAY |
| 2   | R1, R2                       | RES, 27Ω, 5%, 0.1W, 0603                   | CRCW060327R0JNEA        | 603            |
| 1   | R3, R18, R19                 | RES, 1.40 kΩ, 1%, 0.1W, 0603               | CRCW06031K40FKEA        | 603            |
| 1   | R4                           | RES, 1.0MegΩ, 5%, 0.1W, 0603               | CRCW06031M00JNEA        | 603            |
| 1   | R5                           | RES, 280Ω, 1%, 0.1W, 0603                  | CRCW0603280RFKEA        | 603            |
| 1   | R9                           | RES, 110Ω, 1%, 0.1W, 0603                  | CRCW0603110RFKEA        | 603            |
| 2   | R10, R13                     | RES, 91Ω, 5%, 0.1W, 0603                   | CRCW060391R0JNEA        | 603            |
| 1   | R11                          | RES, 47 kΩ, 5%, 0.1W, 0603                 | CRCW060347K0JNEA        | 603            |
| 1   | R12                          | RES, 100 kΩ, 1%, 0.1W, 0603                | CRCW0603100KFKEA        | 603            |
| 4   | R14, R15, R16, R17           | RES, 49.9Ω, 1%, 0.1W, 0603                 | CRCW060349R9FKEA        | 603            |
| 1   | U1                           | LM8335 supplied by Texas Instruments       | LM8335                  | DSBGA-16       |
| 1   | U2                           | IC RF RCVR MSP430 48VQFN                   | MSP430F5510IRGZR        | S-PVQFN-N48    |
| 1   | U3                           | IC 74LVC8T245PWR                           | IC 74LVC8T245PWR        |                |
| 1   | U4                           | Micropower 50 mA Low Dropout 5-pin SOT23   | LP2980AIM5-3.3/NOPB     | TMD04CEA       |
| 2   | U5, U6                       | Micropower 200 mA Low Dropout              | LP5990TM-1.8/NOPB       | TMD04CEA       |
| 1   | VDDIO2                       | Narrow Base Post HJeaders, .100            | 3-644695-3              | IDC3_INLINE    |
| 1   | X1                           | Crystal 8 Mhz                              | CA-301 8.0000M-C:PBFREE | CA-301         |

## 8 LM8335 EVM Schematic

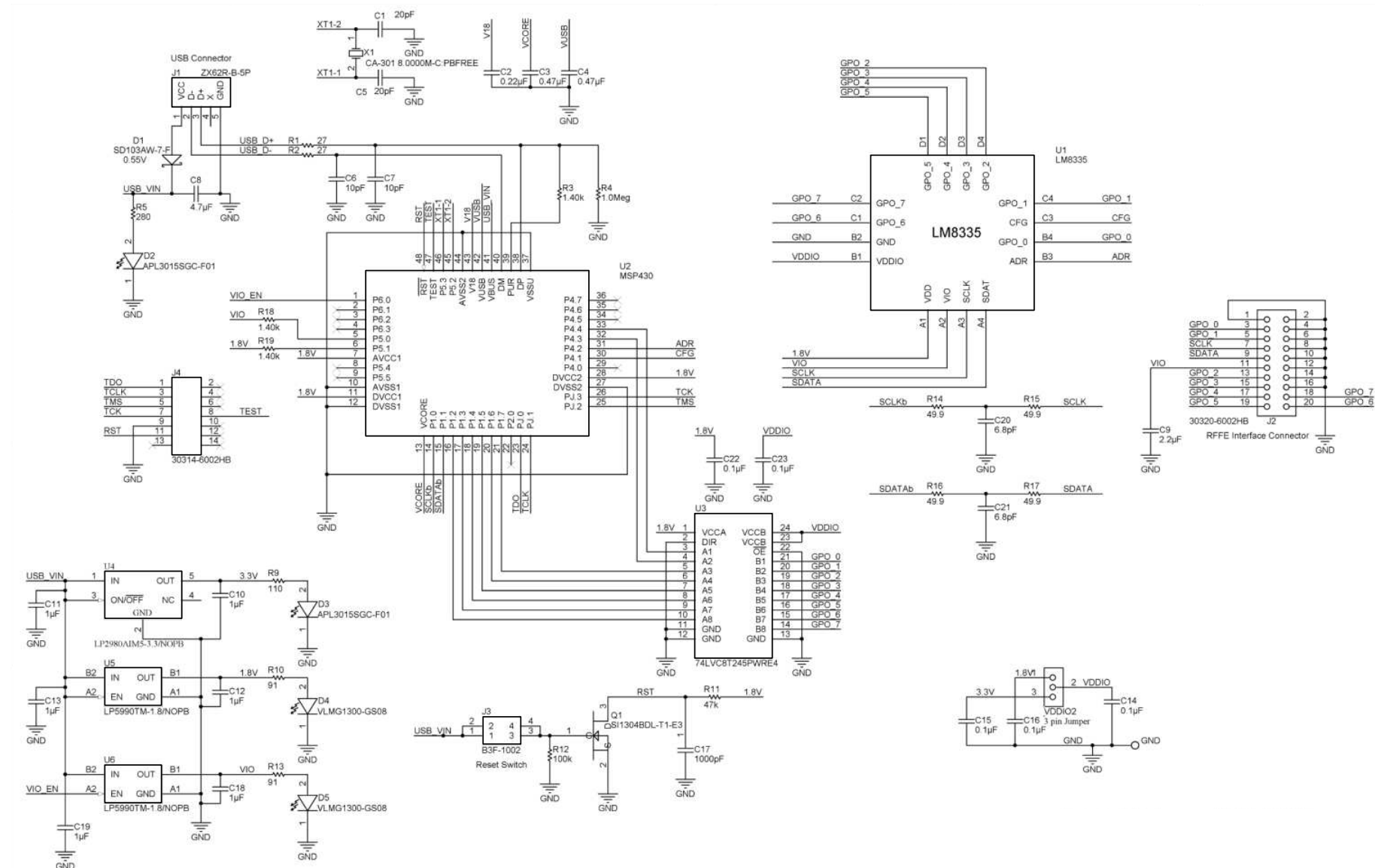


Figure 10. LM8335 EVM Schematic

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

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- 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

- 2 *Limited Warranty and Related Remedies/Disclaimers:*

- 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
- 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
- 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

- 3 *Regulatory Notices:*

- 3.1 *United States*

### 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

### 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

## CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

## FCC Interference Statement for Class A EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

## FCC Interference Statement for Class B EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

## 3.2 Canada

### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

#### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

#### Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

#### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

## 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。  
[http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_01.page)

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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#### 4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

##### 4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMS are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMS, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.



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